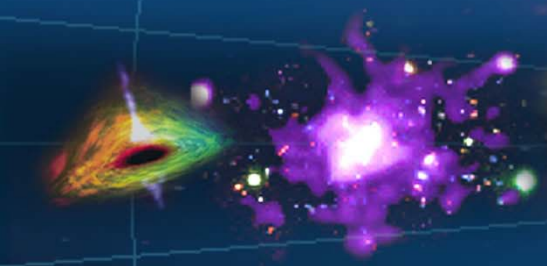
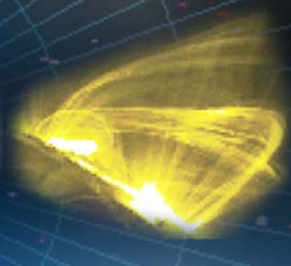
BEYOND EINSTEIN: From the Big Bang to Black Holes



Constellation X

The Constellation X-Ray Mission



Project Update

Presented by
Jean Grady (GSFC)

Facility Science Team Meeting (FST)
February 21 – 22, 2008 / Boulder, Colorado

Highlights Since Last FST Meeting (December 2006)

- **Updated mission concept for single satellite (Atlas V launch) to accommodate recommendations from December 2006 FST meeting:**
  - **Includes both X-ray Grating Spectrometer (XGS) and Hard X-ray Telescope (HXT) with updated performance requirements**
  - **XMS field of view increase**
- **Supported the National Research Council's (NRC) Beyond Einstein Program Assessment Committee (BEPAC) review process, with comprehensive information on Con-X (November 2006 – May 2007)**
  - **Science**
  - **Technology development status and plans**
  - **Mission, instrument and spacecraft risks**
  - **Instrument and spacecraft technical details and schedules**
  - **Operations plans**
  - **Cost estimates and budget requirements**
- **Technology Development milestone progress in following areas:**
  - **Spectroscopy X-ray Telescope mirror X-ray test**
  - **Microcalorimeter multiplexing and position sensitive devices**
- **Recently received FY08 Budget; small increment over FY07**

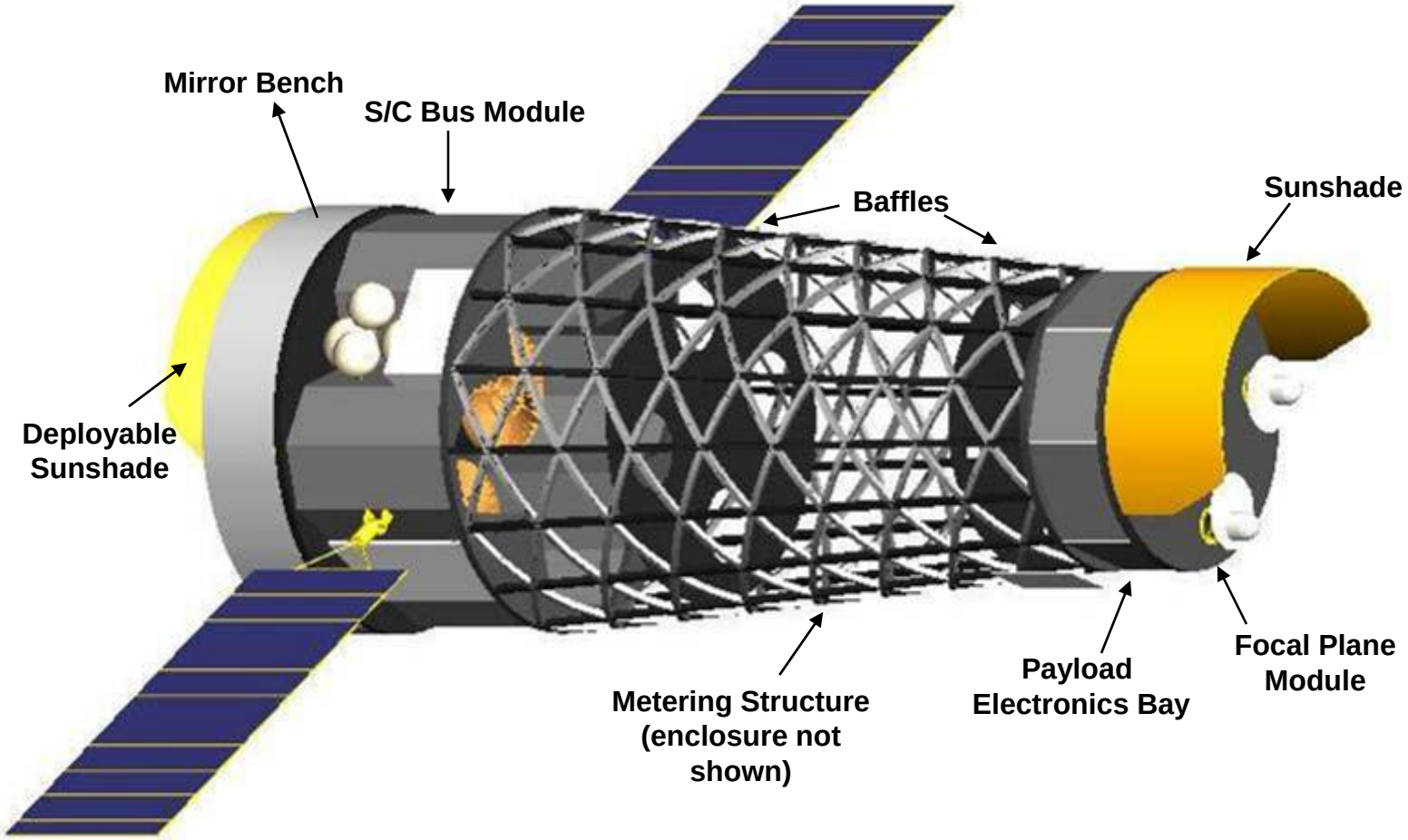
Summary Top Level Con-X Science Performance Requirements

Effective Area:	**15,000 cm^2 @ 1.25 keV** **6,000 cm^2 @ 6 keV** **150 cm^2 @ 40 keV**
Bandpass:	**0.3 – 40 keV**
Spectral Resolution:	**1250 @ 0.3 – 1 keV** **2400 @ 6 keV**
Angular Resolution	**15 arcsec 0.3 – 7 keV** **30 arcsec 0.7 – 40 keV**
Field of View	**5 x 5 arcmin**

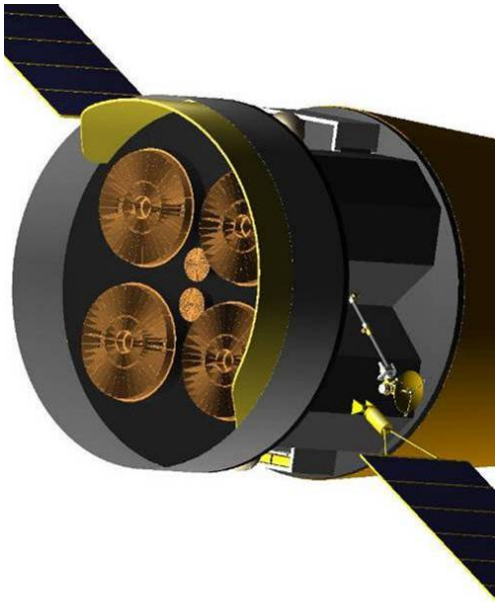
Single Launch Atlas V Mission Configuration

- "Reference" payload
  - Four (4) SXT Flight Mirror Assemblies (FMA's) with X-ray Microcalorimeter Spectrometers (XMS's) at each focus
    - Provides required area, spectral resolution and FOV from 0.6 to 10 keV
  - Hard X-ray Telescope (1 or 2) systems
    - Mirrors can be glass segmented or nickel full-shell
  - X-ray Grating Spectrometer (on 1 or more SXT's)
    - Either Off-plane reflection gratings or Critical Angle Transmission gratings
- Overall spacecraft system requirements well within state-of-the-art
  - All spacecraft requirements can be met with existing technology, no technology development required
- Observatory Mass
  - 30 % overall reserve on launch mass
  - Small additional margin

Observatory Configuration (Single Atlas V Launch)

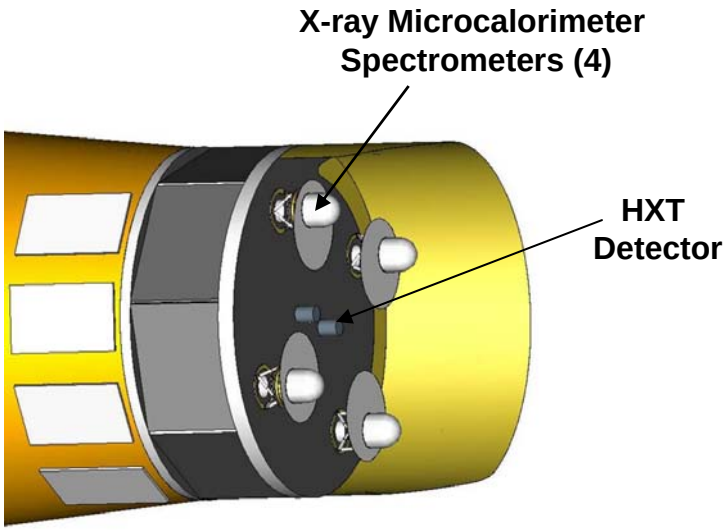


Payload Accommodations



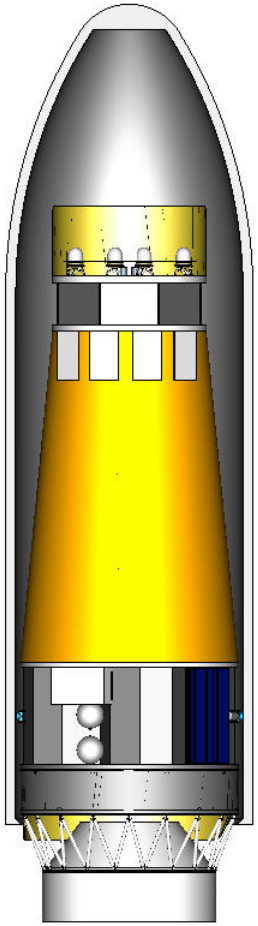
- **Mirror Accommodations**
  - Four 1.3 m dia SXT FMA's and 1 - 2 HXT Mirrors co-aligned on Mirror Bench
  - Sunshade keeps sun light off mirrors
  - Heaters maintain mirrors at room temperature
  - Mirror covers provide protection during launch and orbit transfer

- **Detector Accommodations**
  - XMS, X-ray Grating focal plane camera (not shown) and HXT detectors mount in Focal Plane Module
  - Payload Electronics Bay for warm electronics and XMS cryocooler
  - Sunshade and cold view to space support <100K on XMS "cryogen-less" cryostat shell
  - Loop heat pipe takes heat from cryocooler



Launch and Mass Summary

Atlas 551
Long Fairing



Atlas Payload
Adapter Fitting

Con-X in Atlas V 551

Payload Mass			
	Estimate (kg)	Estimate (kg)	Allocation (kg)
Flight Mirror Assembly	1572.0	30%	2043.6
X-ray Microcalorimeter Spectrometer	708.0	30%	920.4
X-ray Grating Spectrometer	100.0	30%	130.0
Hard X-ray Telescope	100.0	30%	130.0
Miscellaneous Payload Items	35.6	30%	46.3
Payload Total	**2515.6**	**30%**	**3270.3**

S/C Bus Mass			
	Estimate (kg)	Contingency	Allocation (kg)
C&DH	92.4	30%	120.1
Attitude Control	68.0	30%	88.4
Communications	30.0	30%	39.0
Mechanisms	146.6	30%	190.6
Structure	981.2	30%	1275.6
Power	104.0	30%	135.2
Propulsion	48.0	30%	62.4
Thermal	186.3	30%	242.1
Harness	188.0	30%	244.4
S/C Bus Total	**1844.5**	**30%**	**2397.8**

Launch Mass Summary			
	Estimate (kg)	Contingency	Allocation (kg)
Payload Total	2515.6	30%	3270.3
S/C Bus Total	1844.5	30%	2397.8
Separation System	164.8	30%	214.3
Observatory Dry Mass	**4524.9**	**30%**	**5882.3**
Propellant Mass	257.4	30%	334.6
Observatory Wet Mass	**4782.3**	**30%**	**6217.0**
Throw Mass: 6305 kg		**Project Margin**	**88.0**

6217 kg Wet Mass

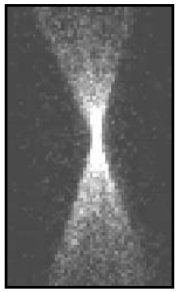
88 kg Margin

30% overall contingency

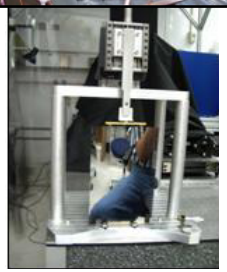
Mirror and Microcalorimeter Technology Highlights

- **SXT Mirror Technology**
  - Demonstrated < 15 arc sec angular resolution of thin glass mirror segments with X-ray test
  - Mirror Segment Alignment and Mount
    - Implemented two types of "temporary" mounting devices: mattress and Cantor tree mount
    - Development tests ongoing for techniques acceptable for a flight-like mount
- **Transition Edge Sensor (TES) Microcalorimeter Technology**
  - Produced uniform 8 x 8 arrays; with best spectral resolution of 2.3 eV
  - Multiplexed 2 x 8 readout of 8x8 array, achieving spectral resolution of
    - ~3 eV overall average
    - 2.6 eV on best pixel
  - Completed fabrication and test of first single pixel Position Sensitive TES's (PoST's)
    - Spectral resolution 5 eV; meets requirement of <8 eV for outer portion of Field of View

Mirror segment pair on cradle in GSFC X-ray test facility

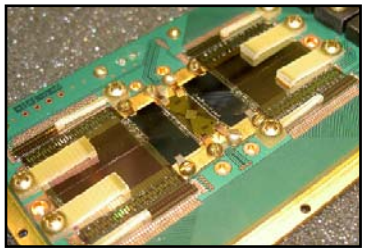


X-ray image

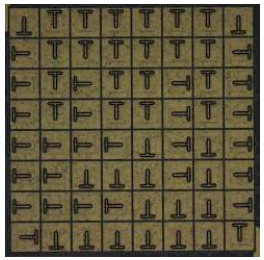


Cantor Tree mount

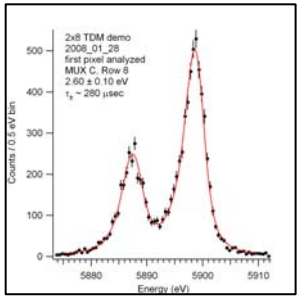
"Cube" Permanent Housing simulator



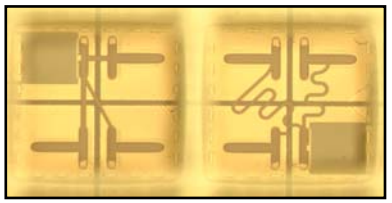
NIST MUX facility with GSFC TES



Uniform 8x8 TES Array

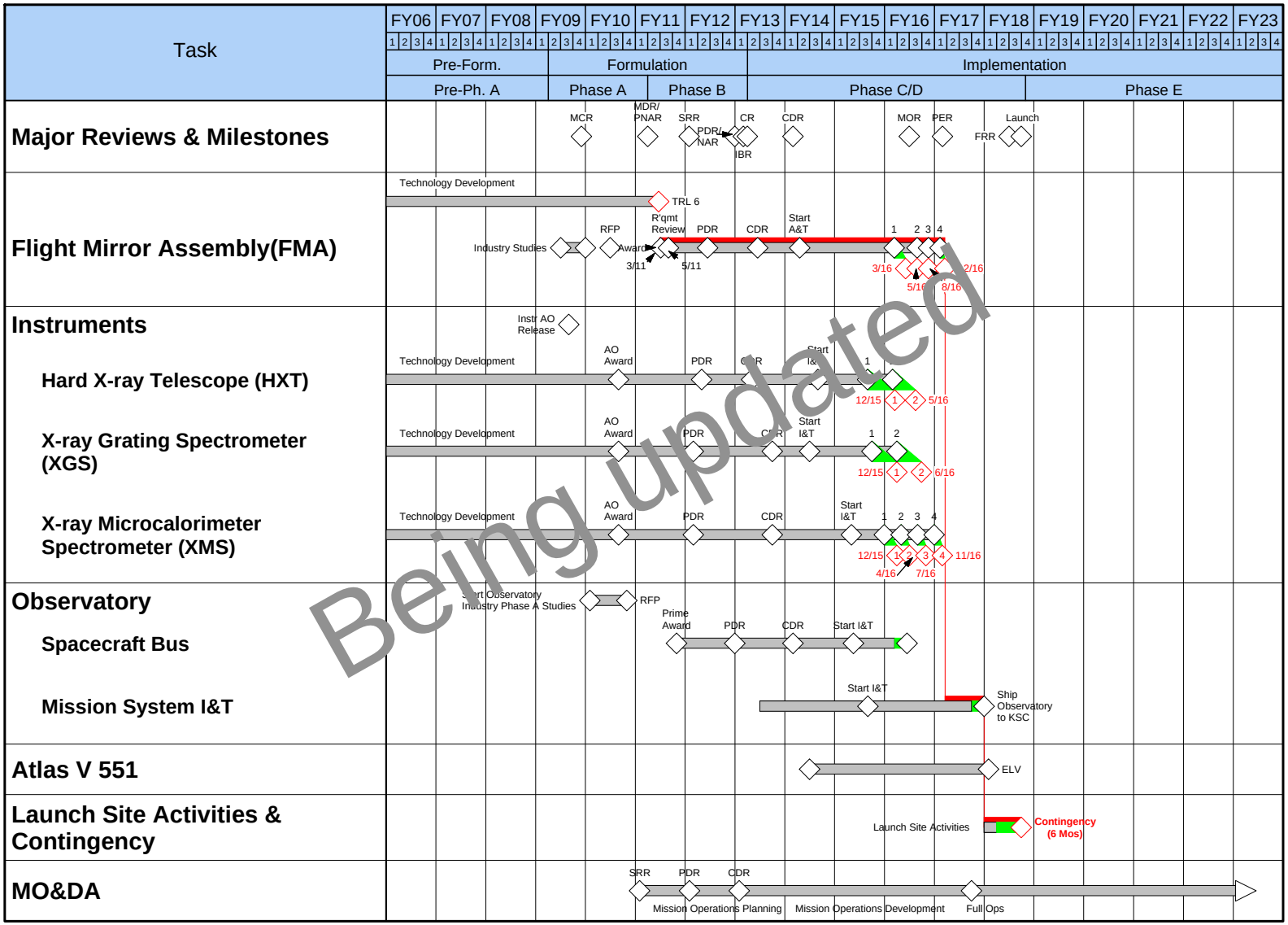


TES mulitiplexing



Single TES PoSTs

Con-X Mission Schedule (in revision for POP08))



Plans for FY08

- **Continue technology development:**
  - SXT Mirror: Emphasis on mounting mirror segments
  - TES: Work toward building and multiplexing larger arrays

- **Mission and Instrument Studies**
  - Update instrument concepts and accommodation in observatory
  - GSFC Instrument Design Lab (IDL) study for XMS; possibly XGS
  - Integrated Mission Design Center to update overall

- **Further develop concept for mirror technology transfer**
  - Document process in a draft plan
  - Engage potential industry partners

- **Update overall mission cost estimates**
  - Complete independent parametric cost estimates for mission (70 % confidence)
  - Perform trades, integrate results from mission and instrument updates